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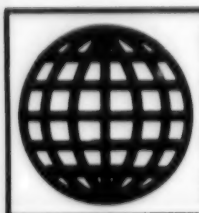
9 DECEMBER 1993



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SUPER HIGH-SPEED, SUPER PARALLEL OPTOELECTRONICS (ABSTRACTS)

JPRS-JST-93-026
9 DECEMBER 1993

SCIENCE & TECHNOLOGY
JAPAN

SUPER HIGH-SPEED, SUPER PARALLEL OPTOELECTRONICS (ABSTRACTS)

43070015E Tokyo TOKYO UNIVERSITY, ADVANCED S&T RESEARCH CENTER REPORT in English Mar 93 pp 1-217

CONTENTS

Basic Studies for Ultrafast Digital Signal Processing

43070015E Tokyo TOKYO UNIVERSITY, ADVANCED S&T RESEARCH CENTER REPORT in English Mar 93 pp 20-23

[Article by Takeshi Kamiya, Department of Electronic Engineering, Faculty of Engineering, Tokyo University]

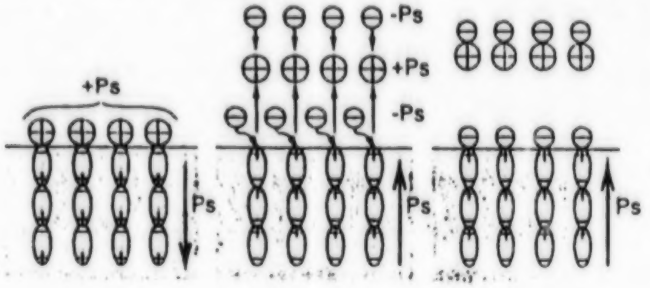
[Excerpt] **Abstract:** The combination of an optical and an electronic device is promising toward the realization of ultrafast digital signal processing. An improvement of ultrashort pulse generation from semiconductor lasers using the soliton pulse compression effect is performed. As a practical application of the ultrafast optical pulses, the electrooptic sampling of the photodiode is performed with improved temporal resolution and sensitivity. The scheme of the optical clock in a digital circuit has the potential advantage of minimizing the difficulty associated with the increasing complexity of electrical interconnection. A design of two channel optically triggered multiplexer is attempted. The importance of the threshold uniformity of switching transistors is pointed out.

Ultrafast Optical Control by Nonlinear Optical Effect

43070015E Tokyo TOKYO UNIVERSITY, ADVANCED S&T RESEARCH CENTER REPORT in English Mar 93 pp 24-26

[Article by Hiromasa Ito, Research Institute of Electrical Communication, Tohoku University]

[Excerpts] **Abstract:** Periodic domain inverted bulk structures are successfully fabricated by means of a direct electron beam writing on $LiNbO_3$ and $LiTaO_3$ substrates at room temperature without any DC bias. The characteristics of the quasiphase matching using these materials are studied experimentally and theoretically. The mechanism of the domain flipping is discussed. Theoretical analysis is also performed to generate tunable submillimeter waves.



(a) before flipping (b) during flipping (c) after flipping

Figure 1. Charge Transfer Near the -z Surface During Domain Flipping

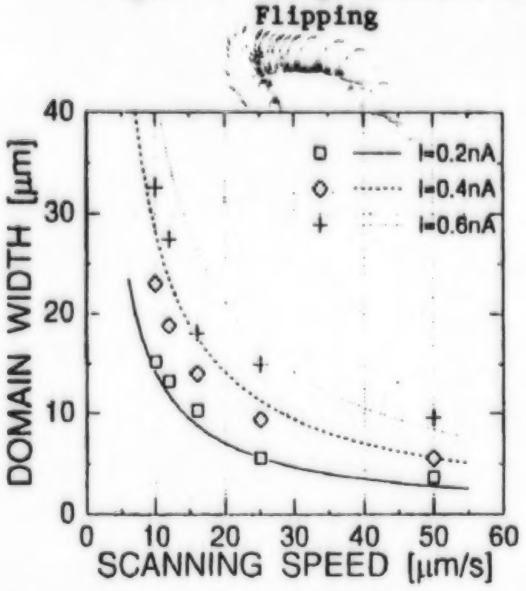


Figure 2. Experimental Data for the Absorption Current Vs. Domain Width Theoretical curves are also shown.

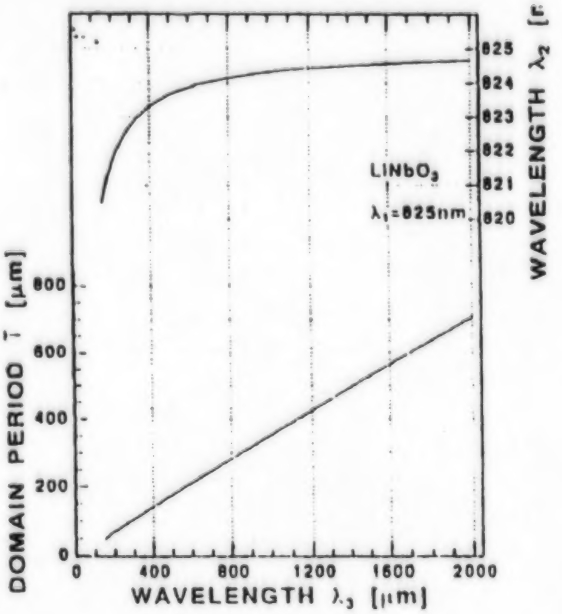


Figure 3. Calculated Period Vs. Submillimeter Wavelength

Optical High-Speed Active Devices by Phase-Conjugation, Optical Bis'ability

43070015E Tokyo TOKYO UNIVERSITY, ADVANCED S&T RESEARCH CENTER REPORT in English Mar 93 pp 28-30

[Article by Naohiro Tanno, Kitoshi Kawaguchi, and Tadayuki Funaba]

[Excerpts] **Abstract**: In this study, we have demonstrated pitchfork like polarization bistability in LDs as a optical switching between TE and TM mode operation. We have also generated multiphase-conjugate and nonconjugate waves with diffraction by two or three beams incident into a coherent resonant two-level system.

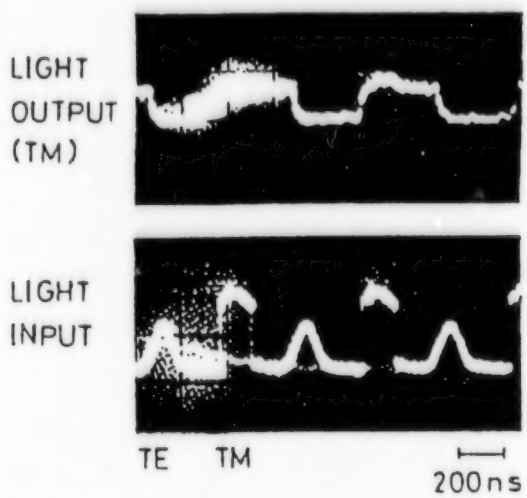


Figure 1. All Optical Flip-Flop Operation

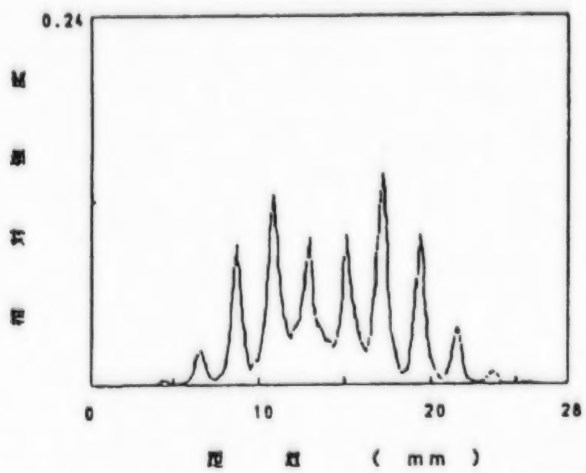


Figure 2. Diffraction Intensity Pattern
Incident power 145 W/cm^2

Optical Glass Fibers With Low Softening Temperature, Nonlinear Effects

43070015E Tokyo TOKYO UNIVERSITY, ADVANCED S&T RESEARCH CENTER REPORT in English Mar 93 pp 31-34

[Article by Yutaka Sasaki and Shunichi Kamemaru, Faculty of Engineering, Ibaraki University, and Tsutomu Yanagawa, NTT Optoelectronics Laboratories]

[Excerpt] **Abstract**: The loss of a silica-based single-mode optical fiber has been reduced, but it has not yet come down to the Rayleigh scattering loss in silica material. The loss gap occurs by the internal stresses in drawing of an optical fiber, that is, the stresses induced thermally and by a drawing tension. We carried on the analysis of structural imperfection losses induced by the internal stresses in a silica-based single-mode fiber, and cleared that the loss of a graded-index structure is lower than that of a simple step-index structure.

Ultrahigh-Speed All-Optical Memories, Switching by Optically Nonlinear Organic Materials

43070015 Tokyo TOKYO UNIVERSITY, ADVANCED S&T RESEARCH CENTER REPORT in English Mar 93 pp 35-39

[Article by Keisuke Sasaki, Faculty of Science and Technology, Keio University]

[Excerpts] **Abstract**: Succeeding research in frequency doubling (SHG) and ultrahigh-speed all-optical switching are developed. Additionally, optical amplification in dye-doped polymer fiber is observed for the first time.

A novel organic crystal: 2-furyl methacrylate anhydride (FMA) is grown and applied for frequency doubling in collinear and nonlinear phase matchings.

Two-photon absorption in all-optical ultrafast switching waveguide is established using 100fs Ti:sapphire laser pulses.

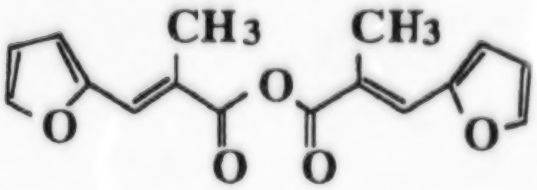


Figure 1. Molecular Structure of FMA

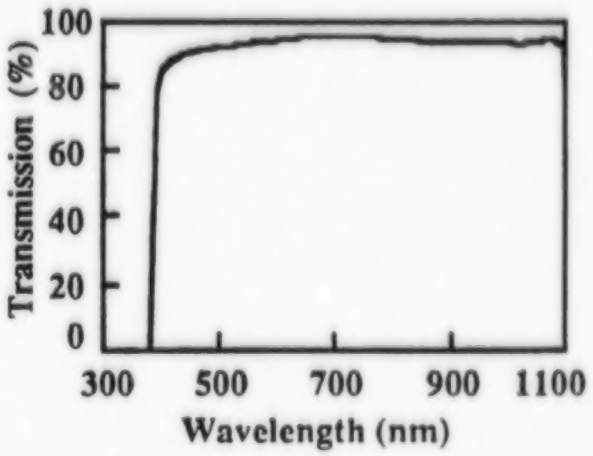


Figure 2. Transmission Spectrum of FMA Crystal

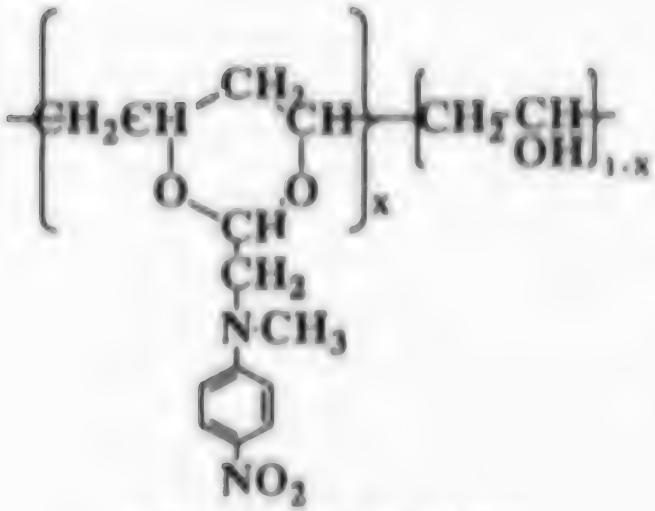


Figure 3. p-HA-PVa Polymer

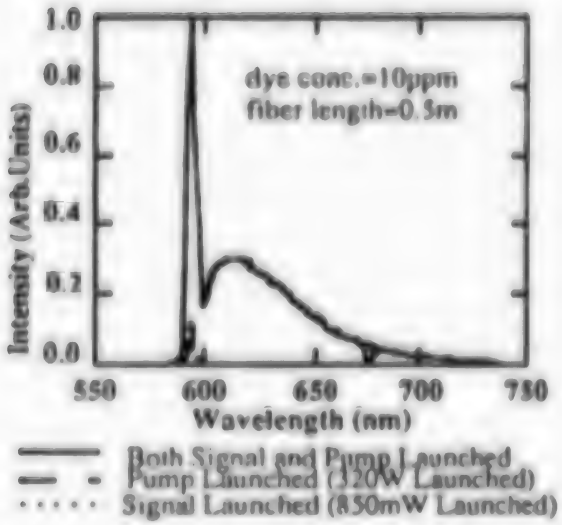
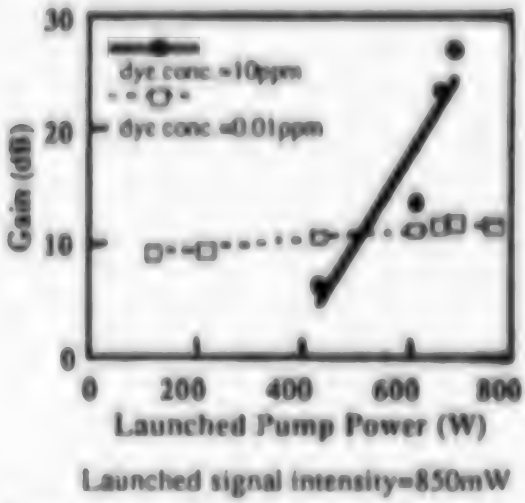


Figure 4. Output Spectra of Rhodamine B Doped Active GI POF



Launched signal intensity=850mW

Figure 6. Signal Gain Against Launched Pump Power for the Rhodamine Doped Active GI POF

Peta-Hertz Class Hyper-Coherence Optical Sweep Generator

430700158 Tokyo TOKYO UNIVERSITY, ADVANCED S&T RESEARCH CENTER REPORT in English Mar 93 pp 40-41

[Article by Motoichi Ohtsu, Interdisciplinary Graduate School of Science and Engineering, Tokyo Institute of Technology]

[Excerpts] **Abstract**: As the study on realizing a very high-coherence and wideband-tunable optical frequency generator, a wideband optical frequency comb generator was improved to be used as a local oscillator to measure the heterodyne frequency between lasers. By using the optical frequency comb generator, we realized difference measurement up to 0.5 THz with a signal to noise ratio higher than 61 dB, and heterodyne optical phase locking with a heterodyne frequency of 0.5 THz. The maximum measurable frequency difference was estimated to be 4 THz.

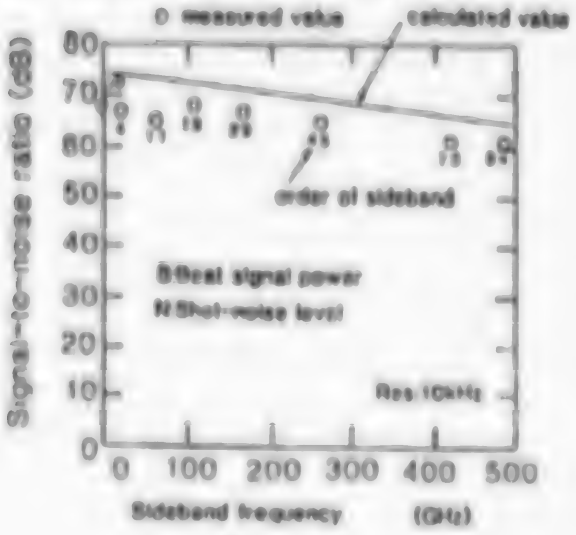


Figure 1.

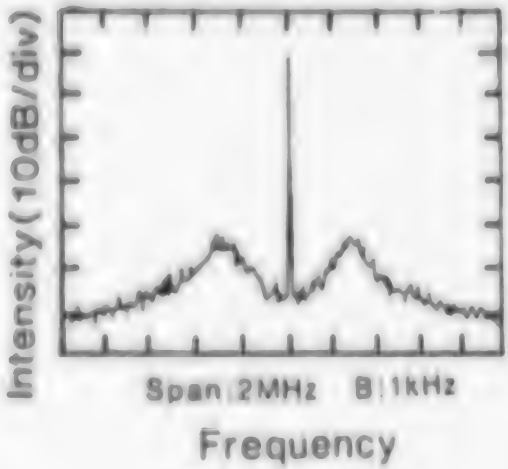


Figure 2.

Parallel Processing Computer in GaAs Optical Devices on Si Substrates

43070015E Tokyo TOKYO UNIVERSITY, ADVANCED S&T RESEARCH CENTER REPORT in English Mar 93 pp 44-48

[Article by Masayoshi Umeno, Takashi Egawa, and Takashi Jimbo, Department of Electrical and Computer Engineering, Nagoya Institute of Technology]

[Excerpts] **Abstract:** We have studied a strain-relieved AlGaAs/InGaAs laser, a waveguide-type optical switch, and a monolithically integrated device grown on an Si substrate by metallo-organic chemical vapor deposition (MOCVD). The strain-relieved AlGaAs/InGaAs laser with the InGaAs intermediate layer showed the lifetime as long as 24 hours under the CW condition at 300 K. The optical switch exhibited 33.1 dB/mm modulation at 867 nm wavelength in -8 V bias. The monolithic integrated device, which consists of laser, metal semiconductor field-effect transistors (MESFET) and p-n photodetector, was also fabricated on Si using the selective regrowth.

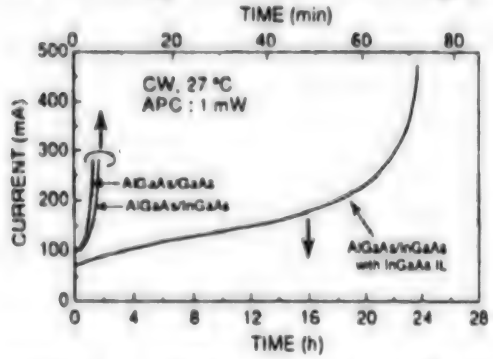


Figure 1. Aging Test of Lasers on Si Under CW Condition at 300 W

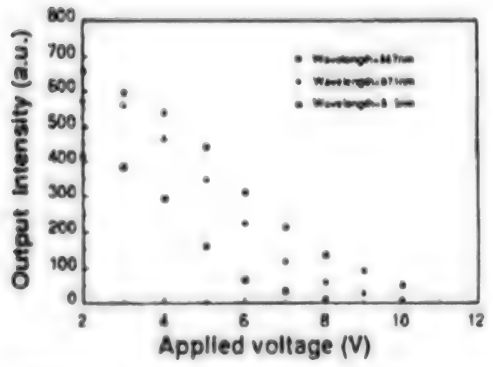


Figure 2. Relationship Between Applied Voltage and Output Density for Optical Switches on Si

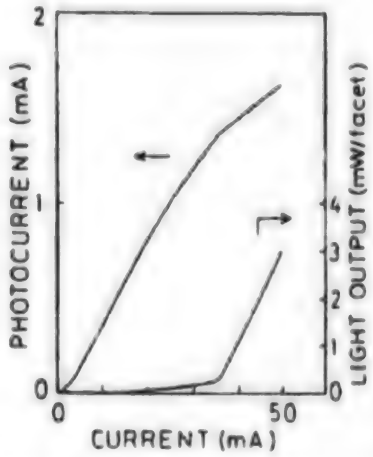


Figure 3. I-L Characteristic of Laser Using External Detector and Photocurrent Monitored by Internal p-n Photodetector

Generation, Control, Processing of Ultrafast Optical Signals

43070015E Tokyo TOKYO UNIVERSITY, ADVANCED S&T RESEARCH CENTER REPORT in English Mar 93 pp 49-51

[Article by Tetsuro Kobayashi, Faculty of Engineering Science, Osaka University]

[Excerpt] **Abstract:** We are developing ultrafast optical techniques to generate, to control, and to process ultrashort optical signals. In the current year, we developed electrooptic modulators, further, which are quasi-velocity matched modulators with a microwave delay line and/or polarization inversion. Modulators using multiple beam interference proposed last year are experimentally studied on the ultrashort pulse ability. The off-resonant coherent interaction between propagating optical pulses and a two-level optical medium is theoretically analyzed for the purpose of ultrafast optical pulse generation and shaping.

Search for New Ultrafast Optical Switching Mechanisms

43070015E Tokyo TOKYO UNIVERSITY, ADVANCED S&T RESEARCH CENTER REPORT in English Mar 93 pp 52-57

[Article by Yasuaki Masumoto, Institute of Physics. Tsukuba University]

[Excerpts] **Abstract:** As a basis for a new polarization-switching optical device, the spin relaxation process of the holes in the type-II AlGaAs-AlAs system is studied. It was found for the first time that the hole-hole collision process is spin-dependent as the result of Pauli's exclusion principle. As the second result, new lasing mechanisms of semiconductors are observed in the ultraviolet spectral region. In CdZnS-ZnS strained layer superlattices, localized exciton states work as the initial state of the laser action. In CuCl quantum dots, on the other hand, the transition from the biexciton state to the exciton state shows the laser action.

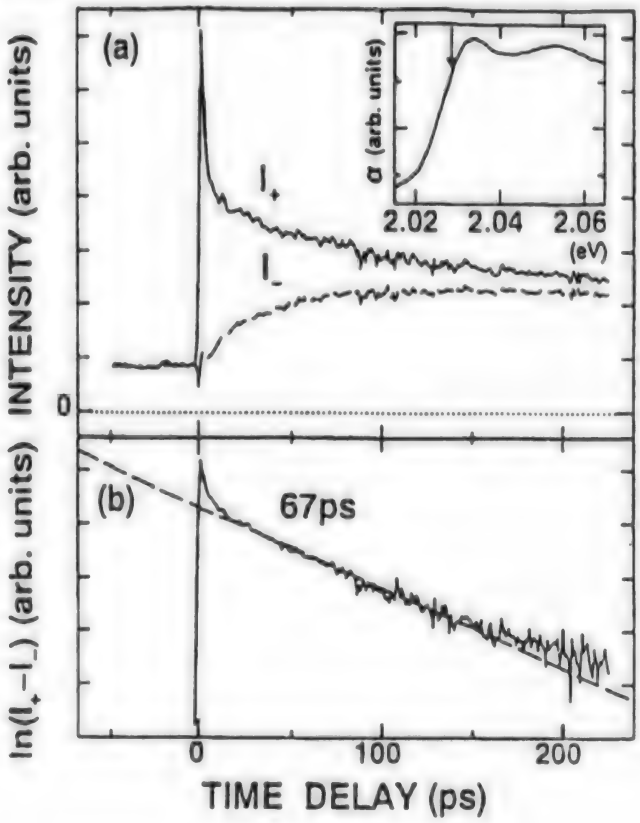


Figure 1. (a) The difference transmission signals observed under the pump of the right circulary polarized light. The pump density is 0.07 $\mu J/cm^2$. Laser repetition rate is 812 kHz The solid line shows the differential transmission signal of the right circularly polarized probe light. The dashed line shows the differential transmission signal of the left circularly polarized probe light. The inset shows the absorption spectrum of the $Al_{0.34}Ga_{0.66}As/AlAs$ multiple quantum wells with arrowed excitation photo energy.
(b) The logarithmic plot of I_+-I_-. The decay of I_+-I_- is fitted by single exponential decay (dashed line).

Study on Ultrafast Nonlinear Optical Phenomena in Semiconductor Lasers

43070015E Tokyo TOKYO UNIVERSITY, ADVANCED S&T RESEARCH CENTER REPORT in English Mar 93 pp 58-60

[Article by Nagaatsu Ogasawara, Kotaro Okamoto, and Koichi Yamaguchi, Department of Electronics Engineering, Electrocommunications University]

[Excerpt] **Abstract**: Operation characteristics of ridge-type and Zn-diffusion-type twin-stripe semiconductor lasers have been measured including beam deflection properties and internal second harmonic generation. Also, feasibility of enhancement of the second-harmonic-generation efficiency has been discussed.

Study on Cubic Nonlinear Optical Elements

43070015E Tokyo TOKYO UNIVERSITY, ADVANCED S&T RESEARCH CENTER REPORT in English Mar 93 pp 61-64

[Article by Ryuji Morita, Hiroyasu Sone, Yasuhiro Sato, and Mikio Yamashita, Department of Engineering Science, Faculty of Engineering, Hokkaido University]

[Excerpts] **Abstract**: We have derived a simple relation between second- and third-order nonlinear optical susceptibilities as a guide for material investigation. We also investigated delayed nonlinear response effect on femtosecond pulse propagation in an organic fiber.

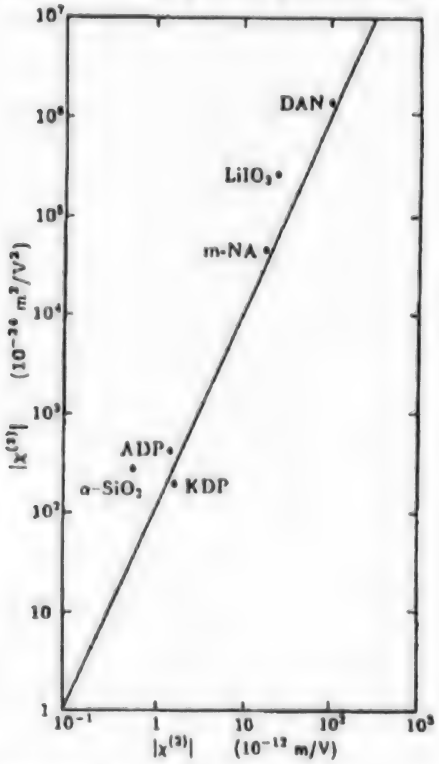


Figure 1. $|\chi^{(3)}|$-$|\chi^{(2)}|$ Relation in Nonresonant Wavelength Region

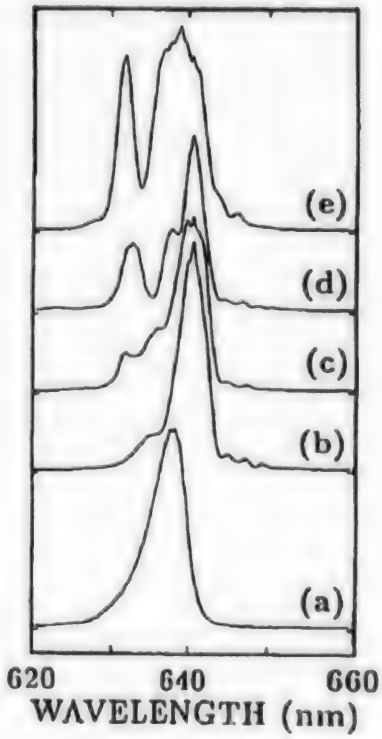


Figure 2 (a). Input spectrum (pulse width: 80 fs, repetition rate: 85.5 MHz, average power 7 mW); (b)-(e) output spectra (average input power 0.2, 1.1, 3.5, 6.4 mW, respectively

Integrated Optics Devices for Signal Processing

43070015E Tokyo TOKYO UNIVERSITY, ADVANCED S&T RESEARCH CENTER REPORT in English Mar 93 pp 65-71

[Article by Hiroshi Nishihara, Masamitsu Haruna, Toshiaki Suhara, and Shogo Ura, Department of Electronics, Faculty of Engineering, Osaka University]

[Excerpt] **Abstract**: Integration of optical waveguide devices for high-speed and parallel signal processing was studied. Various integrated devices, e.g., wavelength filters, position sensors, and second higher harmonics generation (SHG) devices were fabricated and demonstrated.

Ultrafast Light Control Devices, Integration

43070015E Tokyo TOKYO UNIVERSITY, ADVANCED S&T RESEARCH CENTER REPORT in English Mar 93 pp 72-74

[Article by Tadasi Sueta, Faculty of Engineering Science, Osaka University]

[Excerpt] **Abstract**: Objective of the present research is to show feasibility of realizing ultrafast light control devices by using optooptic and electrooptic coupling, and also of realizing their integration to materialize intricate functional devices. Adoptability of band operation instead of conventional baseband one was studied to construct electrooptic light control devices in 30-40 GHz frequency range. Novel $LiNbO_3$ waveguides were tested to be grown by using an liquid phase epitaxy (LPE) method on $LiTaO_3$ substrates. Performance of nonlinear optic waveguide junctions with partial nonlinearity were studied theoretically, and basic characteristics of the semiconductor doped glass waveguides and semiconductor MQW waveguides were examined experimentally.

Integrated Semiconductor Lasers With Composite Functions

43070015E Tokyo TOKYO UNIVERSITY, ADVANCED S&T RESEARCH CENTER REPORT in English Mar 93 pp 75-79

[Article by Kunio Tada, Yoshiaki Nakano, Yukihiro Shimogaki, Nong Chen, and Tsuyoshi Nishikawa, Department of Electronic Engineering, Tokyo University]

[Excerpts] **Abstract:** A novel wavelength tunable semiconductor laser, utilizing a chirped grating for enhancing the tunability of distributed feedback (DFB) laser, was studied for coherent optical communication systems and other applications. The theoretical and experimental analysis on the threshold conditions and tuning properties have shown an enhanced tunability of the proposed chirped grating tunable (CGT) DFB lasers. The double diffusions technique for fabrication of the heterobipolar transistor structure optical switch and other optical integrated devices had been also investigated. Zn and Sn were used as the dopant, and bipolar transistor was successfully developed in GaAs substrate by this diffusion technique.

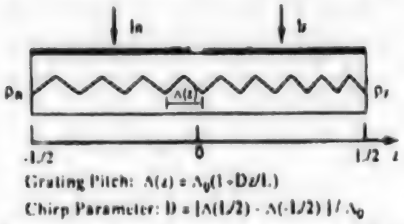


Figure 1. Theoretical Model for Simulation

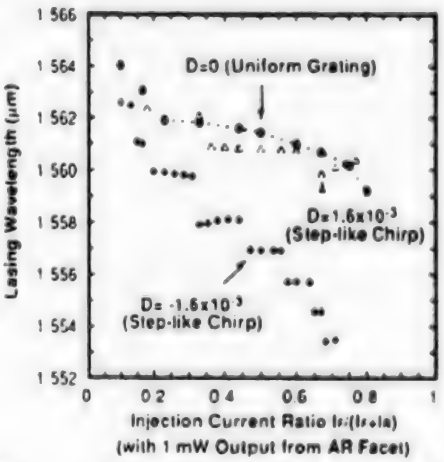


Figure 2. Example of Simulated Results

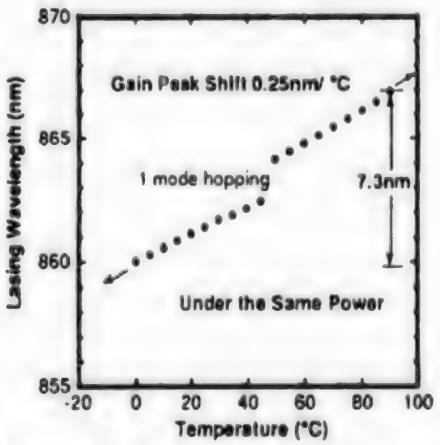


Figure 3. Experimental Thermal Tuning Characteristics of CGT-DFB Laser

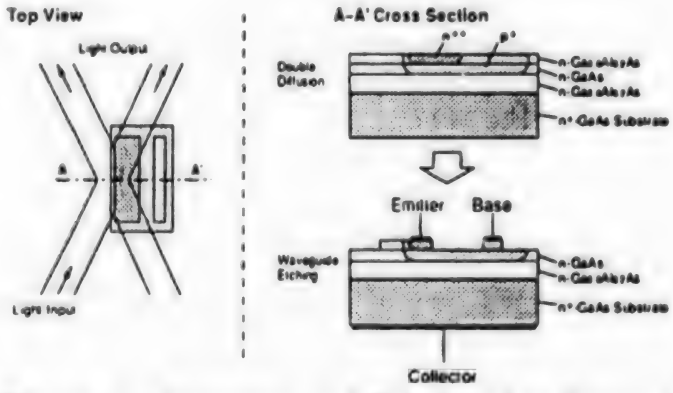


Figure 4. Structure and Fabrication Process of GaAs/GaAlAs Double Hetero Transistor Structure Optical Switch

High-Performance, Optical Isolator

43070015E Tokyo TOKYO UNIVERSITY, ADVANCED S&T RESEARCH CENTER REPORT in English Mar 93 pp 80-82

[Article by Yoshiyuki Naito and Tetsuya Mizumoto, Faculty of Engineering, Tokyo Institute of Technology]

[Excerpts] **Abstract:** To realize a waveguide optical isolator, based nonreciprocal phase shift, magnetooptic materials are investigated. The characteristics of rare earth iron garnet $(LuNdBi)_3(FeAl)_5O_{12}$ grown by liquid phase epitaxy (LPE) are examined being focused on the in-plane magnetization property. Dependence of magnetic and/or optical properties on the growth temperature is discussed. the magnetic field required to saturate the magnetization in-plane has been reduced to 5 Oe.

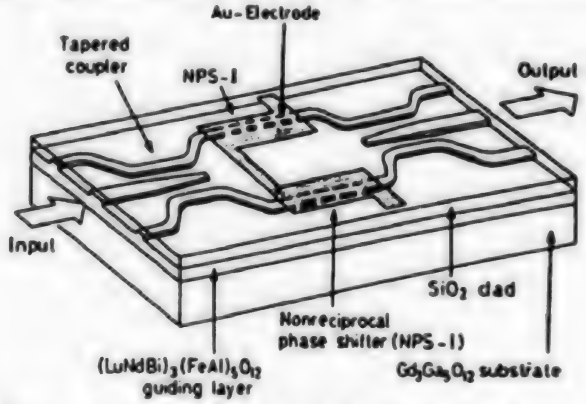


Figure 1. Structure of Optical Isolator Employing Nonreciprocal Phase Shift

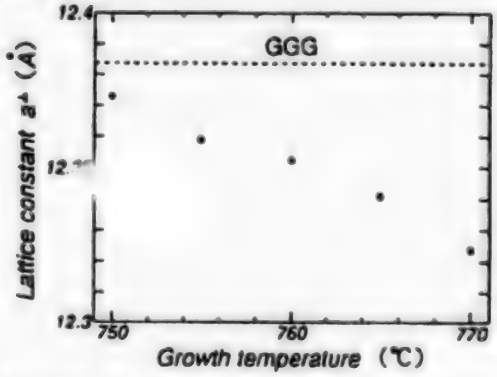


Figure 2. Lattice Constant Vs. Growth Temperature

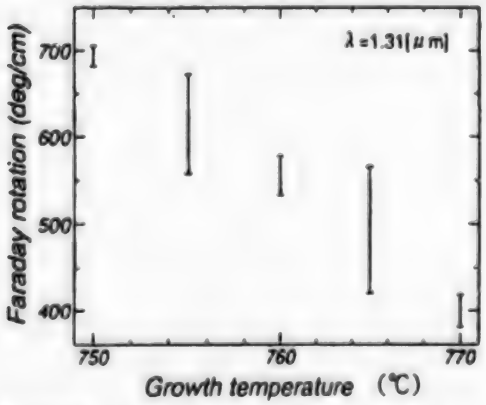


Figure 3. Faraday Rotation at λ=1.31 μm Vs. Growth Temperature

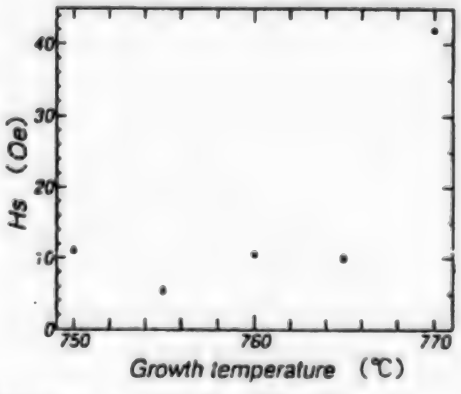


Figure 4. Hs Vs. Growth Temperature

Improvement of Semiconductor Optical Modulator

43070015E Tokyo TOKYO UNIVERSITY, ADVANCED S&T RESEARCH CENTER REPORT in English Mar 93 pp 83-87

[Article by Kazuhito Furuya, Shigehisa Arai, and Yasuyuki Miyamoto, Department of Electrical and Electronic Engineering, Tokyo Institute of Technology]

[Excerpt] **Abstract**: The multidimensional quantum-size structure is very useful for the performance improvement of the laser and the switch/modulator. To realize this multidimensional quantum-size structure, we have developed the ultrafine fabrication technology using electron beam lithography. X-ray lithography and atomic manipulation by scanning tunnel microscope (STM) were also studied to make the smaller structure.

Ultrafast, Ultra-Parallel Functional Optical Devices

43070015E Tokyo TOKYO UNIVERSITY, ADVANCED S&T RESEARCH CENTER REPORT in English Mar 93 pp 88-92

[Article by Yasumitsu Miyazaki, Toyahashi University of Technology]

[Excerpts] **Abstract**: In optical ultrafast and parallel processing, various high-quality functional optical devices are indispensable. We have studied optical devices, such as MSSW mode conversion devices, optical neural devices, optical amplifier devices, second higher harmonics generation (SHG) devices, collinear acoustooptic devices, and tapered waveguide couplers, from a viewpoint of efficiency and dense integration.

Cultivation of Highly-Performed Semiconductor Optical Switch

43070015E Tokyo TOKYO UNIVERSITY, ADVANCED S&T RESEARCH CENTER REPORT in English Mar 93 pp 93-96

[Article by Minoru Yamada, Faculty of Technology, Kanazawa University]

[Text] **Abstract**: Improvements of electron depleting absorption control (EDAC) semiconductor optical switch/modulator have been achieved. The panel-type EDAC devices were integrated into 6x8 array-structure for development f optical parallel processing. Another possibility to make electron depleting index control (EDIC) phase modulator was also examined.

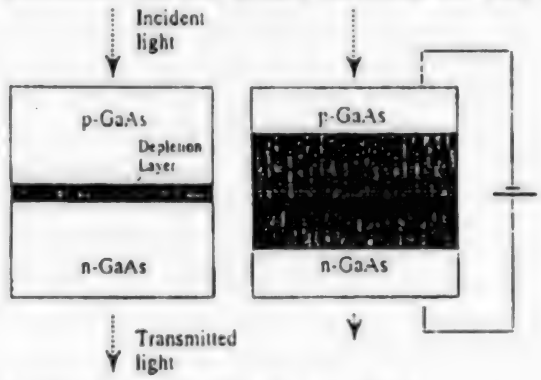


Figure 1. Mechanism of EDAC Modulator

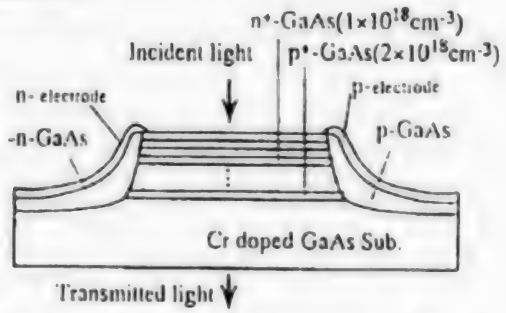


Figure 2. Cross Section of Single Element EDAC

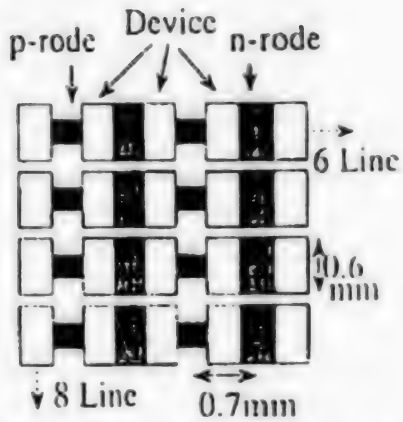


Figure 3. Two-Dimensional Array of Panel-Type EDACs

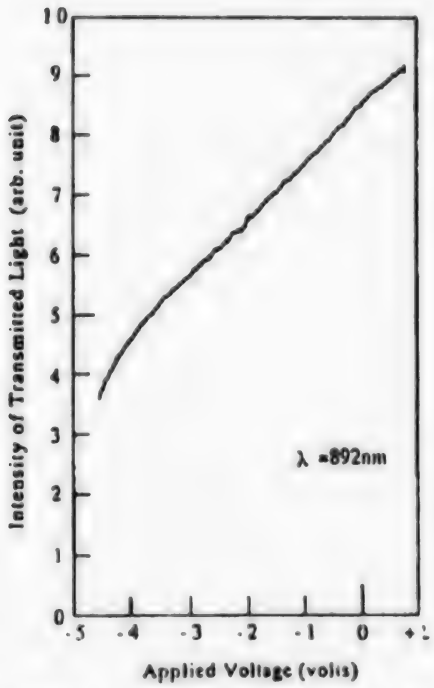


Figure 4. Extinction Ratio of Single Element in Two-Dimensional Array EDAC

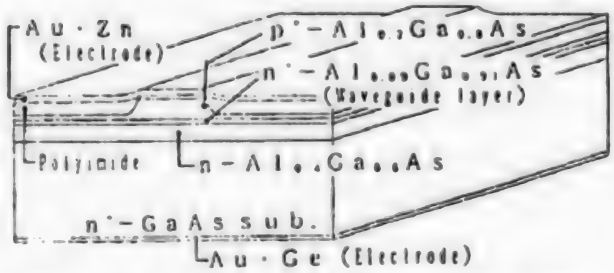


Figure 5. Structure of Waveguide-Type EDIC Phase Modulator

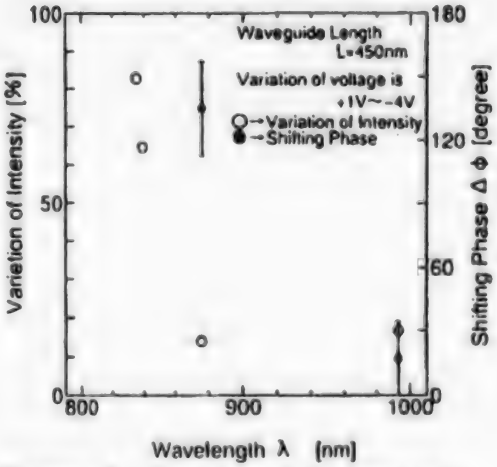


Figure 6. Phase and Intensity Changes in EDIC Phase Modulator

Study on Ultrahigh-Speed Optical Modulation-Demodulation Scheme

43070015E Tokyo TOKYO UNIVERSITY, ADVANCED S&T RESEARCH CENTER REPORT in English Mar 93 pp 97-99

[Article by Masamitsu Nakajima and Young Kyu Choi, Department of Electronics, Faculty of Engineering, Kyoto University]

[Excerpts] **Abstract**: For high-speed optical modulation, we employed conventional interferometric waveguide modulators which are fabricated in cascade. We also developed a general equation in the case that a number of modulators are connected in series. Along with this high-speed modulation, we investigated the possibility of high-speed demodulation utilizing the nonlinearities of a photodetector as an optoelectronic mixer which improved the detection efficiency.

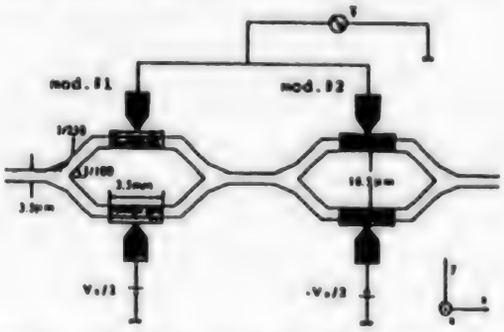


Figure 1. Two-Stage Cascaded Interferometric Optical Modulator

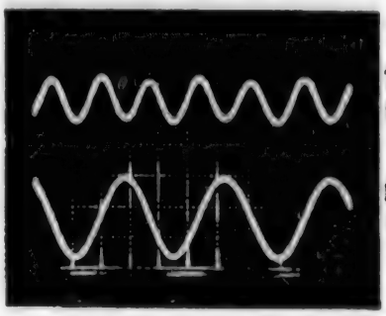


Figure 2. Output Waveform of Two-Stage Cascaded Modulator

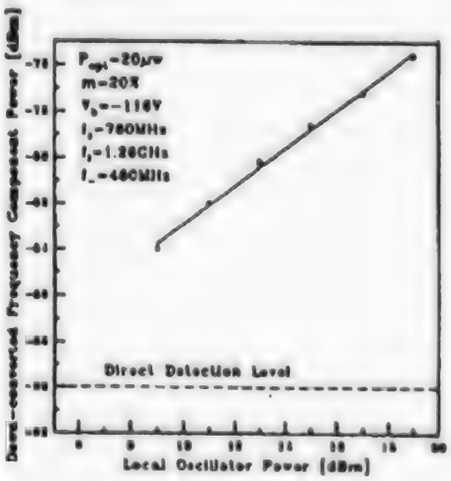


Figure 3. Result of Down-Converting Detection Using APD

Fundamental Study on Organic Optoelectronic Devices

43070015E Tokyo TOKYO UNIVERSITY, ADVANCED S&T RESEARCH CENTER REPORT in English Mar 93 pp 100-103

[Article by Tetsuo Tsutsui, Graduate School of Engineering Sciences, Kyushu University]

[Excerpts] **Abstract:** The emission efficiency of organic thin film electroluminescent (EL) devices is investigated in comparison with that in inorganic-semiconductor emission diodes. The efficiencies of organic EL devices are found to be very high and can even be improved up to more than 10%. Emission characteristics of EL devices with microcavity structure is analyzed and the possibility of control of emission spectra and emission patterns using reflective metallic mirrors is demonstrated.

Fundamental Study of Quantum-Wire Semiconductor Laser Amplifiers

43070015E Tokyo TOKYO UNIVERSITY, ADVANCED S&T RESEARCH CENTER REPORT in English Mar 93 pp 104-106

[Article by Masahiro Asada and Kazuhiro Komori, Faculty of Engineering, Tokyo Institute of Technology]

[Excerpt] **Abstract:** As the first step to realize quantum-wire semiconductor laser amplifiers, we developed a new fabrication method of quantum wires and fabricated GaInAs/InP quantum wires with very small size and high density. We observed blue shifted photoluminescence at room temperature and polarization dependent photoluminescence from quantum wires.

Study of High-Speed Optical Devices Based on Strained Superlattices

43070015E Tokyo TOKYO UNIVERSITY, ADVANCED S&T RESEARCH CENTER REPORT in English Mar 93 pp 107-109

[Article by Ikuo Suemune, Faculty of Engineering, Hiroshima University]

[Excerpt] **Abstract:** High-speed semiconductor lasers are expected with strained-layer superlattices (SLS). Band parameters in the SLS are dependent on the strain and the relationship needs to be clarified for designing the heterostructures. The strain dependencies were analyzed and were utilized for evaluating radiative and Auger recombinations. Measured laser properties were examined based on the theoretical results and interface fluctuations were pointed out as one of the major factors to influence the laser properties. Atomic layer epitaxy is the important technique to solve this problem.

Two-Dimensional Parallel Optical Devices

430700151E Tokyo TOKYO UNIVERSITY, ADVANCED S&T RESEARCH CENTER REPORT in English Mar 93 pp 110-117

[Article by Kenichi Iga, Tokyo Institute of Technology, P&L Laboratory]

[Excerpt] Abstract: Performances of surface emitting lasers and planar microlens array have been improved and their application systems have been considered, which will be the key technologies for the realization of a large-scale two-dimensional parallel optical device and integrated photonic circuits.

Techniques for Ultralong Span Optical Fiber Communications, Ultramultiplex Data Distribution

430700151E Tokyo TOKYO UNIVERSITY, ADVANCED S&T RESEARCH CENTER REPORT in English Mar 93 pp 118-121

[Article by Takanori Okoshi and Shinji Yamashita, RCAST, Tokyo University, and Kazuro Kikuchi, Faculty of Engineering, Tokyo University]

[Excerpt] Abstract: We pursue the essential limitations of transmission distance and capacity in optical fiber communications. In FY1992, the following subjects have mainly been studied: 1) elongation of the transmission distance due to f'ber dispersion compensation, (2) noise characteristics of the system with optical repeater amplifiers, 3) stimulated Brillouin scattering in optical fiber communications, 4) noise characteristics of the optical fiber amplifiers and their improvement, and 5) coherent techniques for the system with optical amplifiers.

Fiber-Integrated Optical Circuits

43070015E Tokyo TOKYO UNIVERSITY, ADVANCED S&T RESEARCH CENTER REPORT in English Mar 93 pp 122-125

[Article by Shojiro Kawakami, Research Institute of Electrical Communication, Tohoku University]

[Excerpts] **Abstract**: We fabricated a fiber-integrated polarization-independent optical isolator and present good characteristics. Changes of the refractive index and absorption of carrier-injected GaInAsP near the band edge, especially at higher energies, are measured.

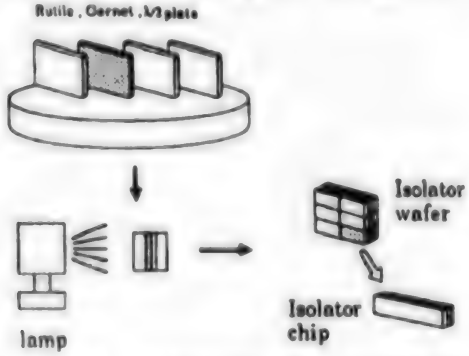


Figure 1. Fabrication Process of Isolator Chip

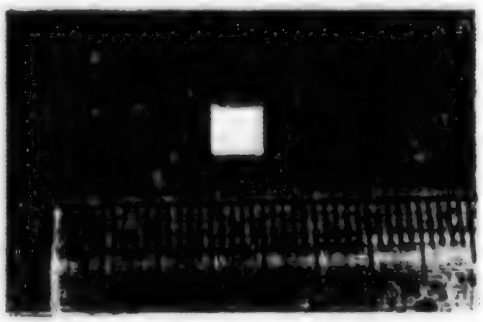


Figure 2. Overview of Isolator Chip

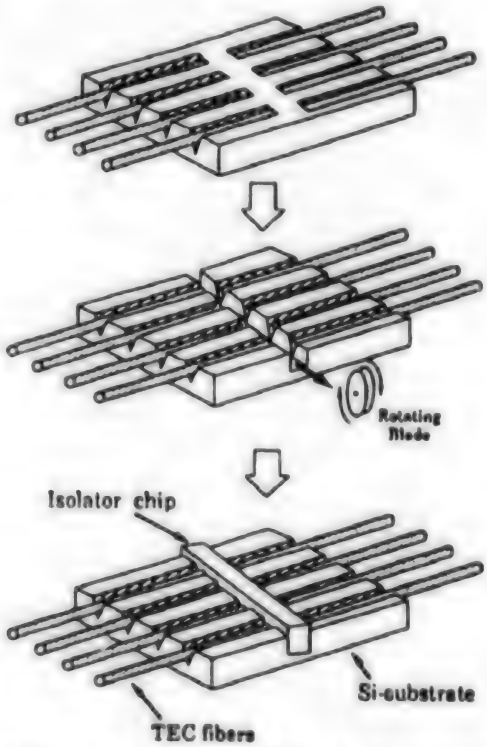


Figure 3. Integration of Isolator Chip Into Fiber Array

Figure 4. Overview of Integrated Isolator

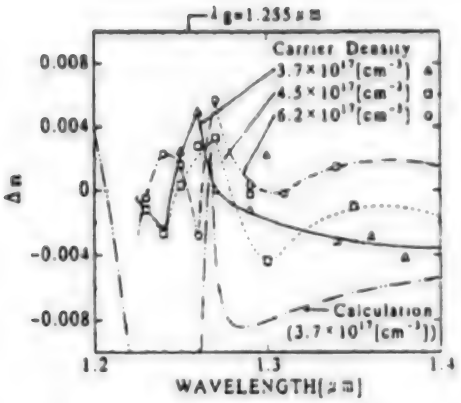


Figure 6. Measured Δn

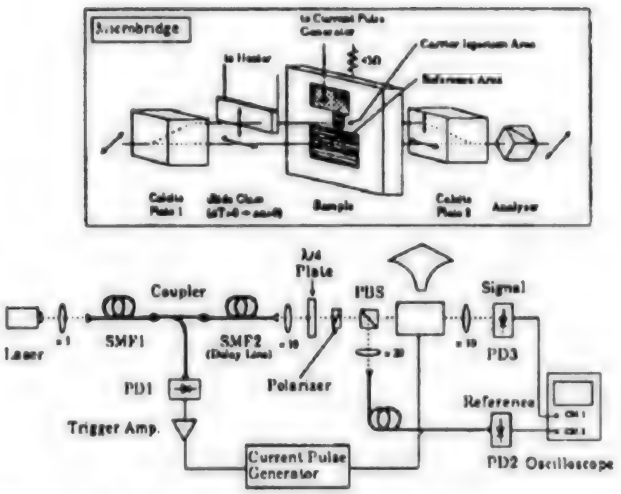


Figure 5. Setup for Measurement of Complex Refractive Index Change

Three-Dimensional Dense Optical Interconnects by Stacked Arrow

43070015E Tokyo TOKYO UNIVERSITY, ADVANCED S&T RESEARCH CENTER REPORT in English Mar 93 pp 126-129

[Article by Yasuo Kokubun, Faculty of Engineering, Yokohama National University]

[Excerpts] **Abstract**: To establish a new technology of three-dimensional optical interconnects, we have developed a stacked configuration of Arrow and reported in the interim report last year. To further advancement of the optical interconnects, we tried to improve the stability of lightwave devices for dense FDM and WDM systems.

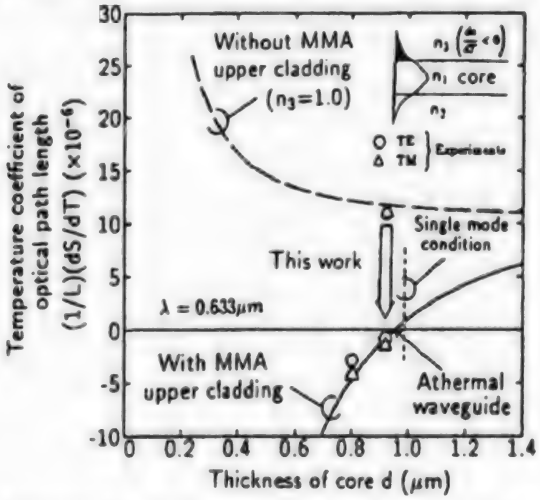


Figure 1. Temperature Dependence of Optical Path Length of a Thermal Waveguide

Efficient Analysis, Design System for Optical Transmission Circuits

43070015E Tokyo TOKYO UNIVERSITY, ADVANCED S&T RESEARCH CENTER REPORT in English Mar 93 pp 130-135

[Article by Masanori Koshiba, Faculty of Engineering, Hokkaido University]

[Excerpt] **Abstract**: The finite-element method is described for modeling and characterizing optical transmission circuits using an interactive computer aided design (CAD) facility which has allowed the numerical approach to move into an industrial research environment where realistic circuit geometries have to be analyzed quickly and efficiently. The application of the finite element method to component design is illustrated by a series of examples.

Super High-Speed Light Transmission by Using Nonlinear Optical Fiber

43070015E Tokyo TOKYO UNIVERSITY, ADVANCED S&T RESEARCH CENTER REPORT in English Mar 93 pp 136-138

[Article by Yoichi Fujii, Institute of Industrial Science, Tokyo University]

[Excerpt] **Abstract**: In this series of the research, the subjects are on the extended study of the nonlinearity in the optical fiber communication system.

The first second topic is the generation of the optical solitons by using the fiber amplifier and the nonlinearity of the solitons. This shows the basic condition of the triggering of the stable short pulse in the ring resonator.

The second one is the possibility of the optical pulse transmission in the femtosecond region. Introducing a generalized nonlinear wave equation, an eigensolution, a "supersoliton," for this wave equation is obtained under a very simple assumption. This shows a new possibility for the super high-speed transmission of the optical signals.

Numerical Analysis of Optical Soliton Systems

43070015E Tokyo TOKYO UNIVERSITY, ADVANCED S&T RESEARCH CENTER REPORT in English Mar 93 pp 139-144

[Article by Kazuo Horiuchi, School of Science and Engineering, Waseda University]

[Excerpt] **Abstract**: Fundamental problems of analyzing characteristics of optical soliton transmission are discussed in this note. In the first place, for the nonlinear Schroedinger equation model, it is briefly reviewed that this model equation can be solved exactly. Using this, several ideas about discretization are explained, which will be useful for developing a new kind of soliton transmission system. Then, a computer assisted analyzing method of optical soliton system sis explained. In this method, self-validating numerics and CG-algorithms are utilized.

High-Speed Semiconductor Lasers With Multidimensional Quantum Well Structures

43070015E Tokyo TOKYO UNIVERSITY, ADVANCED S&T RESEARCH CENTER REPORT in English Mar 93 pp 145-150

[Article by Y. Arakawa and Y. Nagamune, IIS, RCAST, Tokyo University]

[Excerpt] **Abstract**: We investigated coherent interaction between excitons and photons in quantum microcavities, demonstrating possibility of vacuum Rabi-oscillation in the semiconductor cavity for the first time. In addition, fabrication technology and optical properties of quantum wires for application to ultrahigh-speed semiconductor lasers are also discussed. Quantum wires with a minimal lateral dimension less than 10 nm are successfully fabricated in terms of metallo-organic chemical vapor deposition (MOCVD) selective growth on SiO_2 patterned substrates.

Fiber-Type Devices for Optical Phase Control, Application to High-Speed Optical Pulse Generation

43070015E Tokyo TOKYO UNIVERSITY, ADVANCED S&T RESEARCH CENTER REPORT in English Mar 93 pp 151-153

[Article by Masaaki Imai, Muroran Institute of Technology; Akira Odajima and Kazushi Motoi, Hokkaido Institute of Technology; and Kunio Kokura, Furukawa Electric Co., Ltd.]

[Excerpts] **Abstract:** Modulation characteristics of optical phase of light propagating in a piezoelectric polymer jacketed Nd-doped active fiber and its application to ultrafast optoelectronics are discussed. A theoretical model is presented for a single-mode silica fiber having a 4.0 μm core and 90 μm cladding diameter, doped with 180 ppmw of Nd^{3+} and jacketed with a piezoelectric VDF(73mol%)/TrFE(27mol%) copolymer radially poled. The experimental data and analyses indicated multiple resonance peaks of phase sensitivity in the frequency range of 50-100 MHz. The resonance peak at 50 MHz range, therefore, will be utilized to investigate the efficient phase modulation in a fiber-type mode locker capable of generating high-speed optical pulses.

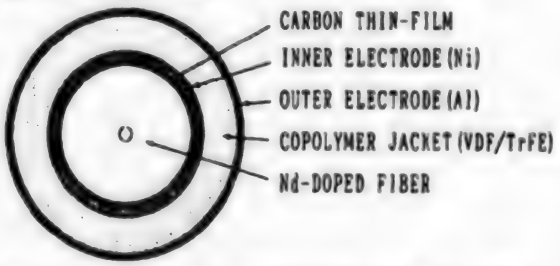


Figure 1. Cross-Sectional View of a Piezoelectric Polymer Jacketed Nd-Doped Active Fiber

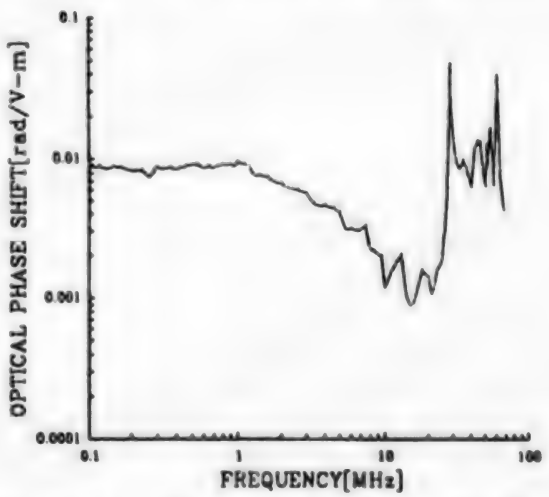


Figure 2. Normalized Optical Phase Shift as a Function of Driving Frequency

Construction of Parallel Digital Optical Computing System, Parallel Algorithms

43070015E Tokyo TOKYO UNIVERSITY, ADVANCED S&T RESEARCH CENTER REPORT in English Mar 93 pp 154-157

[Article by Yoshiki Ichioka, Faculty of Engineering, Osaka University]

[Excerpts] **Abstract:** An experimental system of an optoelectronic hybrid optical parallel array logic system, called H-OPALS 16^2, is constructed. On the system 16 x 16 pixels are processed in parallel at the rate of 20 kframes/sec. An alternative system, called P-OPALS, is also considered, which is based on spatial light modulators and operated by pure optical methods. As a technique of parallel software, local variable logic (LVL) is studied to compensate optical array logic.

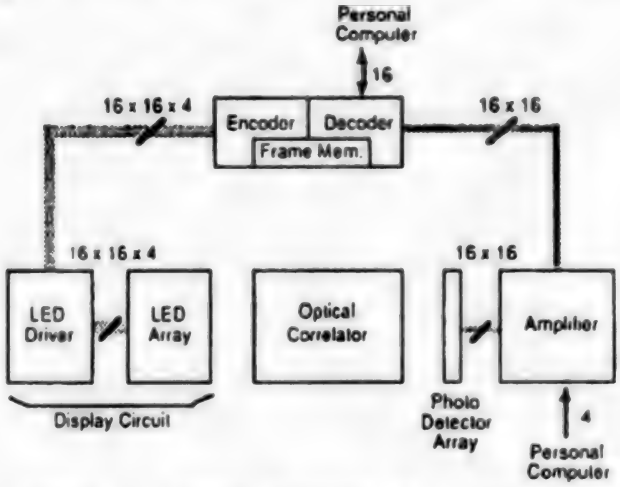


Figure 1. Block Diagram of H-OPALS 16^2

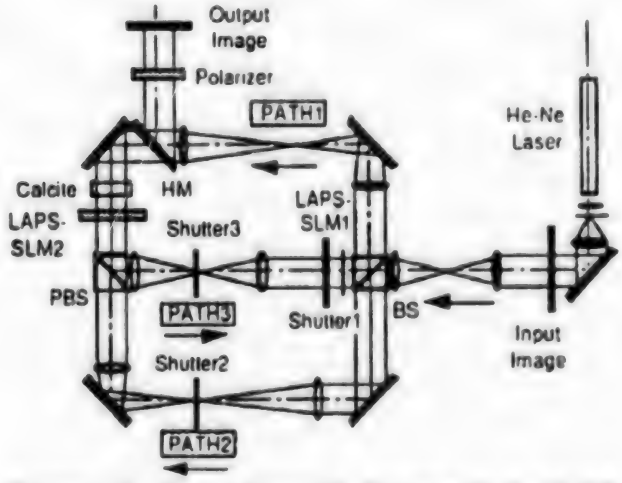


Figure 2. Experimental Setup of P-OPALS

Optical Neural Computing System Using Ferroelectric Liquid Crystal

43070015E Tokyo TOKYO UNIVERSITY, ADVANCED S&T RESEARCH CENTER REPORT in English Mar 93 pp 158-160

[Article by S. Kobayashi and Y. Iimura, Division of Electronic and Information Engineering Faculty of Technology, Tokyo University of Agriculture and Technology]

[Excerpts] **Abstract:** The basic operation of an optical neural computing system with five neurons and an optical logic operation using double-layered FLCD has been demonstrated. The system consists of a striped FLC panel for neurons output and an optical mask for weight matrix. The operation corresponds to that of the Hopfield type neural network model. The optical logic operation is applied to implement the operations for recollecting of optical neural computing and the operation is successfully confirmed.

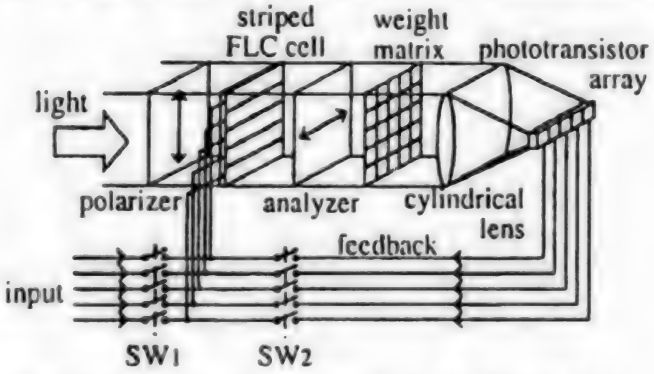


Figure 1. Schematic Drawing of Operation Principle for Recollecting

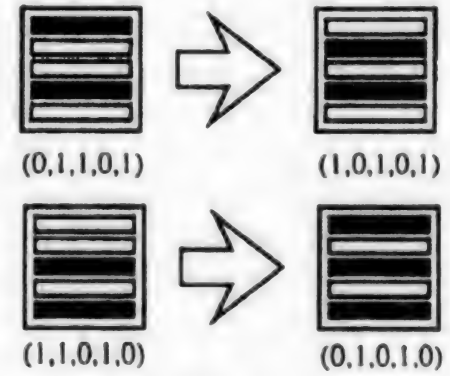


Figure 2. Examples of Recollecting

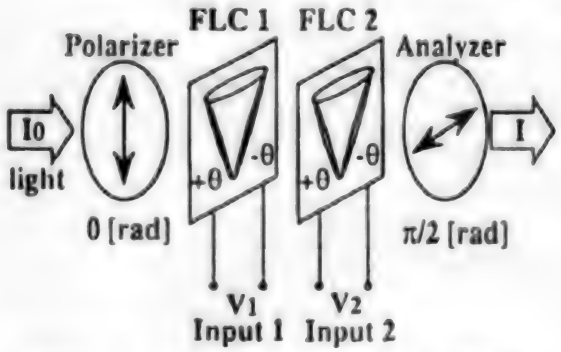


Figure 3. Setup for Optical Logic Operation

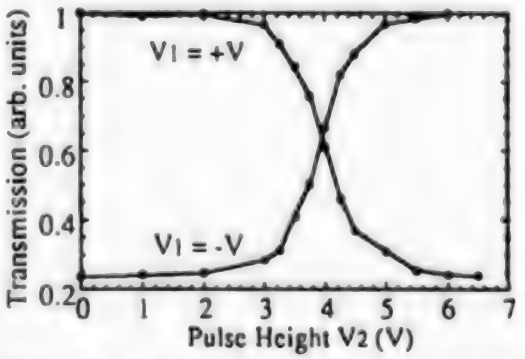


Figure 4. Result of Measurement of Setup of Figure 1 Using Grey-Scale Capability

Display Systems, Data Compression of Autostereoscopic Three-Dimensional Images

43070015E Tokyo TOKYO UNIVERSITY, ADVANCED S&T RESEARCH CENTER REPORT in English Mar 93 pp 161-163

[Article by Joji Hamasaki, Graduate School, East Asia University, and Hiroyuki Sakaki and Mitsuo Okada, Institute of Industrial Science, Tokyo University]

[Excerpt] **Abstract:** To develop display systems of autostereoscopic three-dimensional images, there are two basic tasks: 1) three-dimensional displays appropriate for binocular vision of human observers, and 2) data compression/restoration/expansion of the data to be displayed to match channel capacities for transmission and storing.

In FY1992, we have obtained the following results:

(1) A new structure of a composite lens-plate (CLP) for a direct-view CRT TV display of autostereoscopic three-dimensional image is proposed and experimentally verified. The structure simplifies the stack arrays of CLP for relaying the stripe images from CRT screen to the back of a lenticular sheet.

(2) An improved scheme of data compression is experimentally demonstrated to obtain more accurate three-dimensional coordinates and brightness data from photographically obtained parallax views. But, to implant the scheme into a real-time processor of a three-dimensional camera system, further investigations are necessary. Evolution strategy is successfully demonstrated in extracting depth data from views. Flippings in a three-dimensional image displayed with sampled views is systematically explained.

Optical Information Processing by Synthesis of Coherence Function

43070015E Tokyo TOKYO UNIVERSITY, ADVANCED S&T RESEARCH CENTER REPORT in English Mar 93 pp 164-166

[Article by Kazuo Hotate, RCAST, Tokyo University]

[Excerpts] **Abstract**: Applications of the synthesis of optical coherence function by using direct frequency modulation of a laser diode have been studied. The first one is the reflectometry to diagnose optical circuits and/or devices, in which the spatial resolution has been improved by compensating fully the nonlinearity of the direct frequency modulation of a three electrode tunable DFB laser, and the measurement of the reflectivity at the fiber connector has successfully been demonstrated. The second application is the optical parallel information processing. A novel coherence function has been synthesized to mask selectively a two-dimensional optical information among three-dimensional information. The principle has also been confirmed in the experiments.

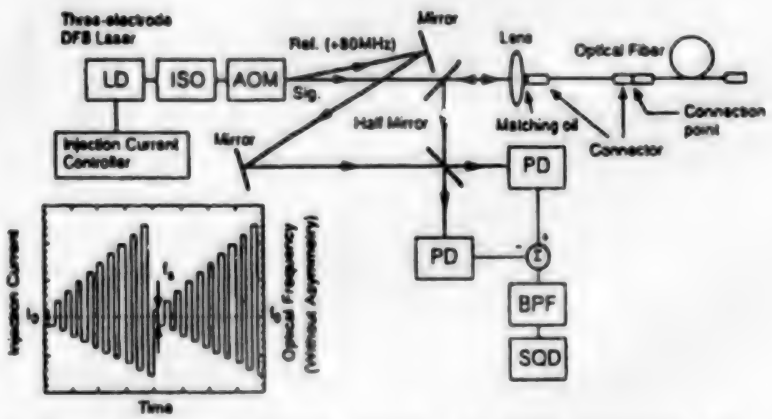


Figure 1. Experimental Setup of Reflectometry by Synthesis of Coherence Function With Full Compensation of Nonlinearity of the Three Electrode DFB Laser and Balanced Detection Scheme

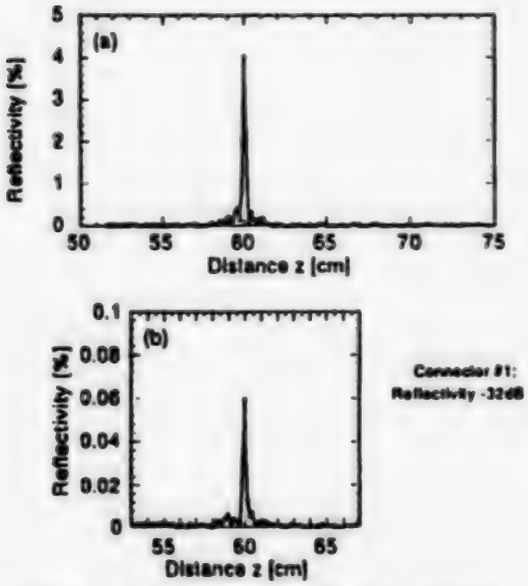


Figure 2. Measurement of Reflectivity at the Fiber Connector
(a) Without, (b) With Connection

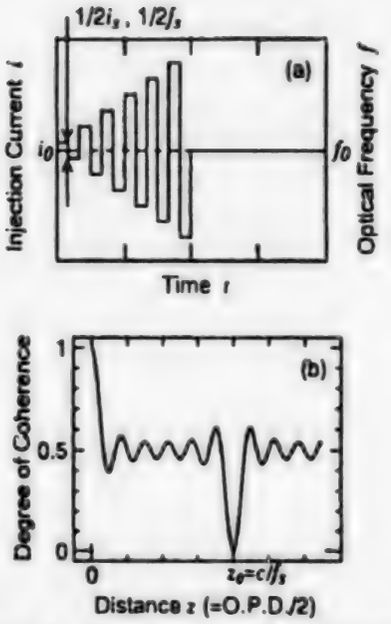


Figure 4. Synthesis of Coherence Function To Mask Selectively a Two-Dimensional Information Among Three-Dimensional Information
(a) Modulation waveform,
(b) Synthesized coherence function

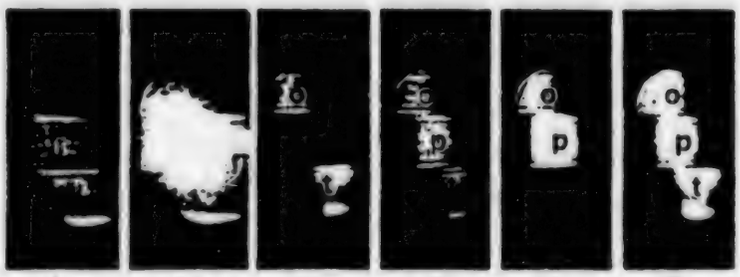


Figure 4. Experimental Demonstration of Masking Selectively Two-Dimensional Information Among Three-Dimensional Information

Optical Parallel Processing, Amplification by Two-Wave Coupling

43070015E Tokyo TOKYO UNIVERSITY, ADVANCED S&T RESEARCH CENTER REPORT in English Mar 93 pp 167-169

[Article by S. Kawata and Y. Kawata, Department of Applied Physics, Osaka University]

[Excerpt] **Abstract**: The progress of our research on image amplification by two-wave coupling in a photorefractive crystal and on three-dimensional (3D) optical memory with photorefractive materials is reported. We have succeeded in recording eleven layers of data in the direction of the optical axis with a photopolymer. The three-dimensional memory with photorefractive crystal is also discussed.

Optoelectronic Integrated Functional Devices

43070015E Tokyo TOKYO UNIVERSITY, ADVANCED S&T RESEARCH CENTER REPORT in English Mar 93 pp 174-178

[Article by Susumi Noda, Kimitaka Shibata, Yasuhiro Kobayashi, and Akio Sasaki, Department of Electrical Engineering, Kyoto University]

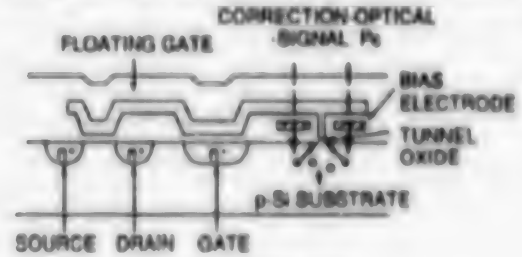
[Excerpt] **Abstract**: An optoelectronic integrated device consisting of four heterojunction phototransistors and a laser diode has been developed. Optical coupling between constituent devices is investigated, and it is shown that there are three coupling modes between any two phototransistors through the laser diode. Various functions based on these optical couplings are demonstrated.

Research on Optoelectronic Neurodevices

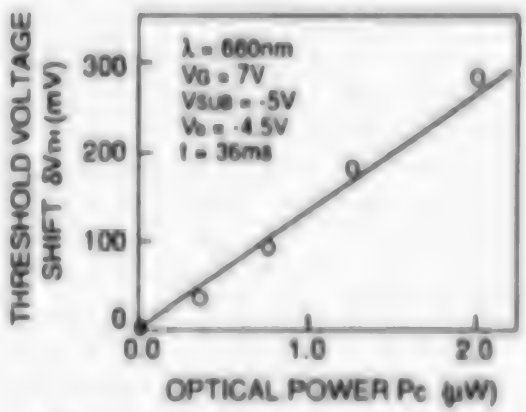
43070015E Tokyo TOKYO UNIVERSITY, ADVANCED S&T RESEARCH CENTER REPORT in English Mar 93 pp 179-182

[Article by Hiroo Yonezu, Department of Electrical and Electronic Engineering, Toyohashi University of Technology]

[Excerpts] **Abstract:** Self-organization by learning was realized in a primitive neural network using the electrical adaptive device. An optical adaptive device was also fabricated for optical-interconnection, in which the threshold voltage was varied according to the optical signal. It was found in hetero-epitaxial lasers for optical-interconnection-devices that dislocation densities are remarkably reduced by introducing a large amount of vacancies in the GaAs on Si and by strained-one-monolayer-superlattices in InGaAs on GaAs.



(a) Cross-sectional view



(b) Threshold voltage shifts as a function of optical power

Figure 1. Adaptive Device Whose Threshold Voltage Is Varied by Optical Signals

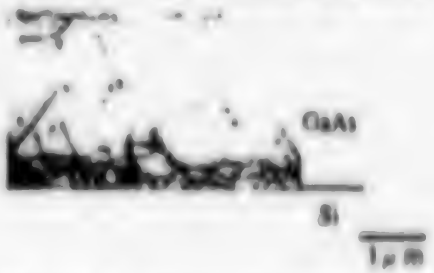


Figure 2. Cross-Sectional TEM Image of Annealed GaAs/Si

Three-Dimensional Optoelectronic IC With Optical Interconnection; Application to Parallel Processing System

430700155E Tokyo TOKYO UNIVERSITY, ADVANCED S&T RESEARCH CENTER REPORT in English Mar 93 pp 183-186

[Article by Mitsumasa Koyanagi, Shin Yokoyama, and Reiji Aibara, Research Center for Integrated Systems, Hiroshima University]

[Excerpts] **Abstract:** A new parallel processing computer system has been proposed. New LSIs with optical interconnections are employed to overcome the problems of bus bottleneck and cache coherency in this new system. It was confirmed using test chips that these memories successfully operate.

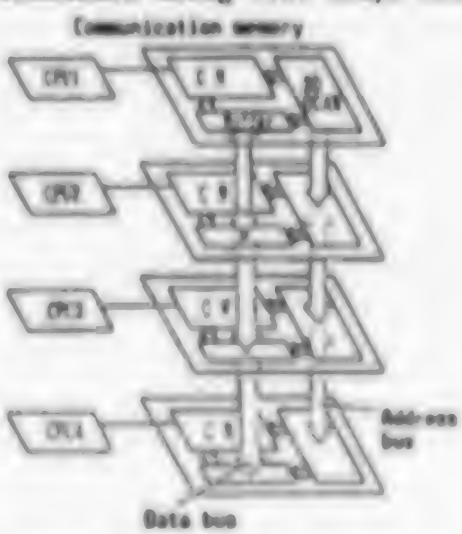


Figure 1. Parallel Processing System

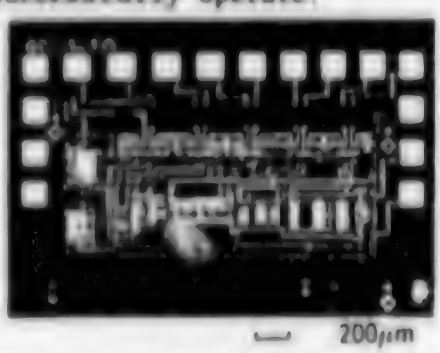


Figure 2. SEM of Test Circuit

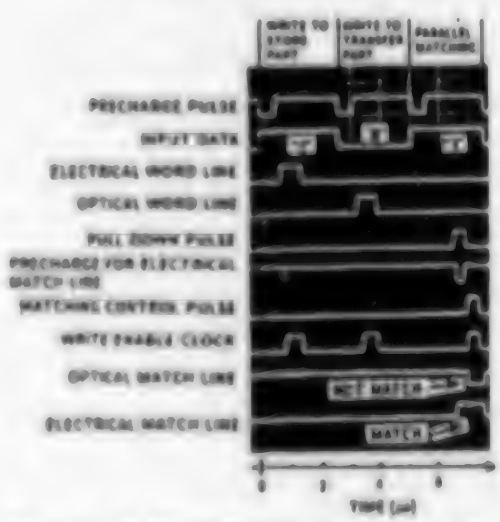


Figure 3. Waveforms of 3D-OCAM

Optical Heterodyne Processing of Multidimensional Images

43070015E Tokyo TOKYO UNIVERSITY, ADVANCED S&T RESEARCH CENTER REPORT in English Mar 93 pp 187-191

[Article by Yoshihiro Ohtsuka, Faculty of Engineering, Hokkaido University]

[Excerpts] **Abstract**: This report describes a novel polarimetric system for mapping the spatiotemporal birefringent parameters to characterize an antiferroelectric liquid crystal cell. This system possesses a reference beam of light with the two-orthogonal linearly polarized components that interfere with their counterpart orthogonal components of an elliptically polarized signal beam, modulated by the liquid crystal cell. Two crossed interference patterns are taken into a CCD TV camera followed by a computer from which a two-dimensional spatiotemporal birefringent pattern is computed. A series of time-dependent birefringent patterns obtained are represented at every 0.2 ms.

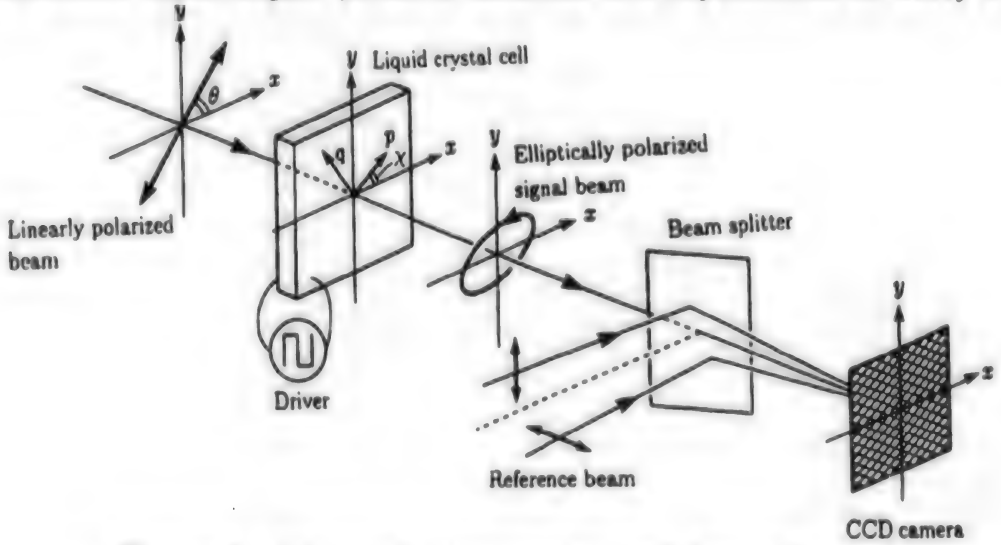


Figure 1. Schematic Illustration for Interference

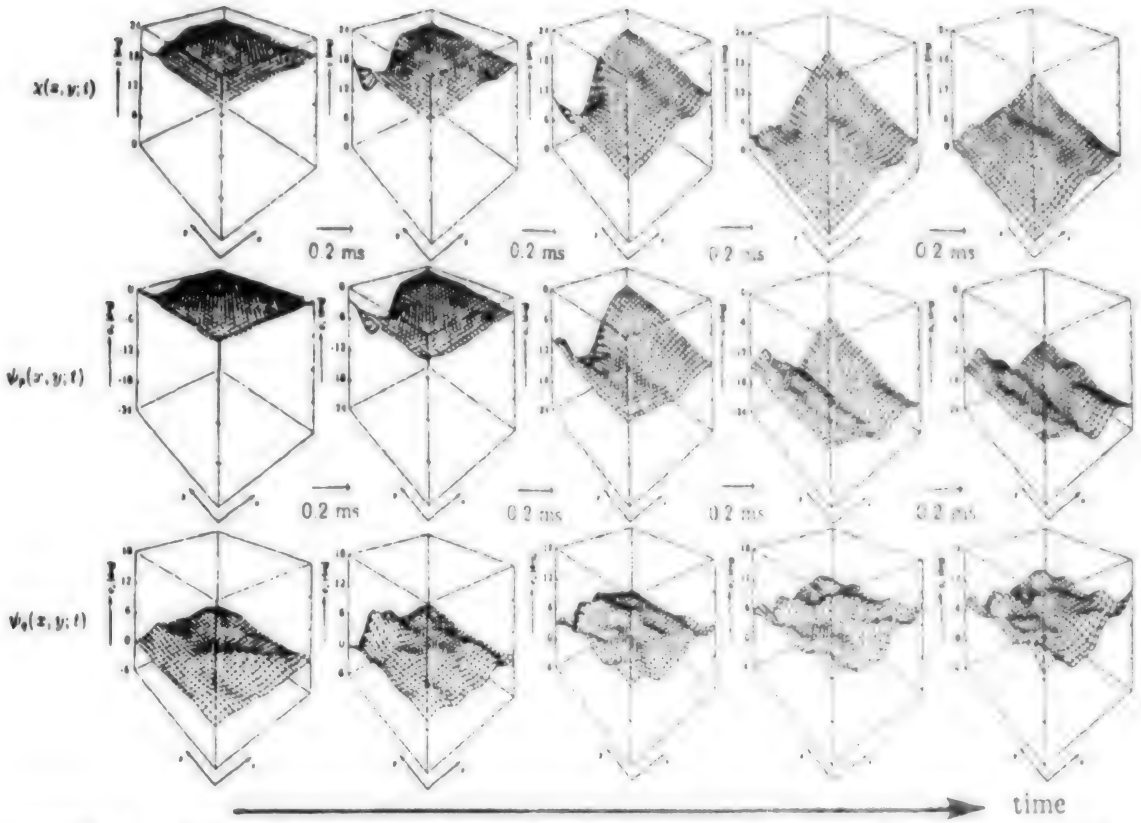


Figure 2. Time Variation in Spatial Distributions of Azimuth and Phases Along the Orthogonal Principal Axes

Evaluation of Prototype of Spectral Imaging System

43070015E Tokyo TOKYO UNIVERSITY, ADVANCED S&T RESEARCH CENTER REPORT in English Mar 93 pp 192-195

[Article by Kazuyoshi Itoh, Faculty of Engineering, Osaka University]

[Excerpts] **Abstract**: A massively-parallel spectral-imager has been evaluated and data processing techniques based on neural network models have been studied. Because of the delay of construction caused by the difficulty of controlling the optical path difference, the imager has not been well evaluated. Yet it is highly probable that the present system achieves the spectral resolution of 3.86 cm^{4}. A self-organizing neural network model for data compression of spectral images that consists of a cascade of two vector-quantizers is evaluated. The first quantizer uses the fixed codebook and the second adaptively changes its codebook. This system has been proved to work 20 times faster than a system with one vector quantizer. Pattern recognition experiments of characters on X-ray films are also reported.

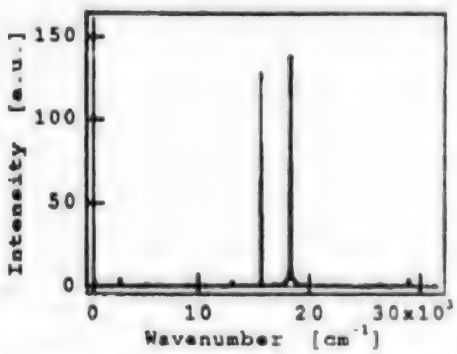


Figure 1. Measured Spectra of Two Different He-Ne Lasers (633 nm, 544 nm)

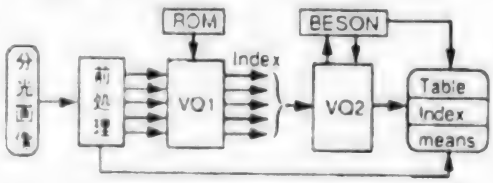


Figure 2. Two-Stage Vector Quantizer

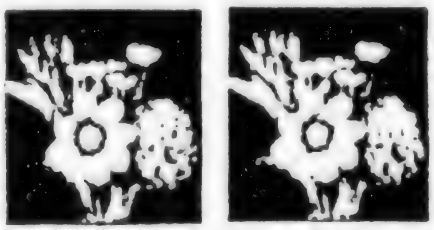


Figure 3. Cross Sections of Spectral Images
(Left) Original
(Right) Compressed

Study on Image Measurement Using Transmitted Light Through Biological Tissues

43070015E Tokyo TOKYO UNIVERSITY, ADVANCED S&T RESEARCH CENTER REPORT in English Mar 93 pp 196-200

[Article by Humio Inaba, Department of Electronics, Faculty of Engineering, Tohoku Institute of Technology]

[Excerpts] **Abstract**: This paper reports an experimental study on laser imaging inside biological tissues and similar turbid media causing strongly multiple scattering using a transmitted light with an apparently straight-path based on the optical heterodyne detection method. Two-dimensional imaging through actual biological samples was performed successfully with excellent spatial resolution.

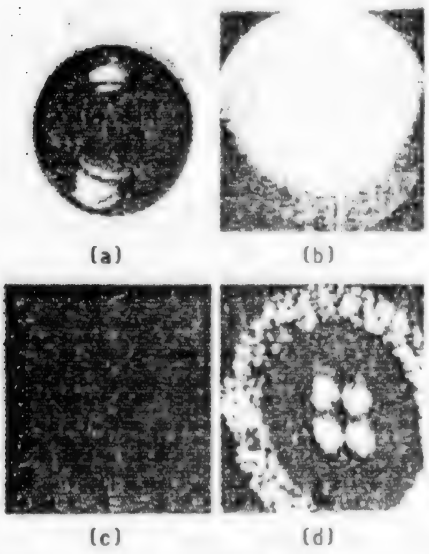


Figure 1. Detected Two-Dimensional Image of a Plastic Button Placed Between Pork Hams With an Nd:YAG Laser

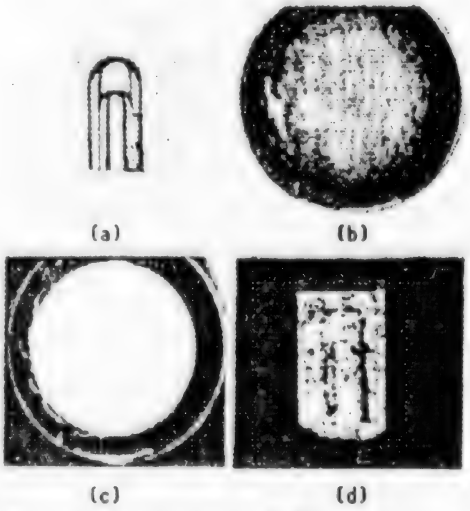


Figure 2. Detected Two-Dimensional Image of a Half-Clip Inserted in Chicken With a Ti:Al_2O_3 Laser

Study on Ultraparallel Image Processing Algorithms, Neural Networks

43070015E Tokyo TOKYO UNIVERSITY, ADVANCED S&T RESEARCH CENTER REPORT in English Mar 93 pp 201-205

[Article by Hidemitsu Ogawa, Faculty of Engineering, Tokyo Institute of Technology]

[Excerpt] **Abstract:** We discuss the over-learning problem for feedforward neural networks in the presence of noise. The authors have already proposed a framework for the discussion of the over-learning problem in the noiseless case. In this paper, we show that the framework is still valid for the noisy case. As an example, we apply the framework to the case in which the rote memorization criterion is used as a substitute of the Wiener criterion. Necessary and sufficient conditions for causing over-learning are given. They show how to choose a training set to prevent over-learning.

Spatiotemporal Multiplexing, Processing of Multidimensional Optical Image Data

43070015E Tokyo TOKYO UNIVERSITY, ADVANCED S&T RESEARCH CENTER REPORT in English Mar 93 pp 206-208

[Article by Mitsuo Takeda, Department of Communication and Systems Engineering, University of Electrocommunications]

[Excerpts] **Abstract:** A complex phase-conjugate neural network model has been proposed, which has a Hopfield-like energy function and a close analogy with the dynamics of self-oscillation generated in a phase conjugate resonator. Experimental results are presented that demonstrate the behavior of the complex neural fields predicted by the theory.

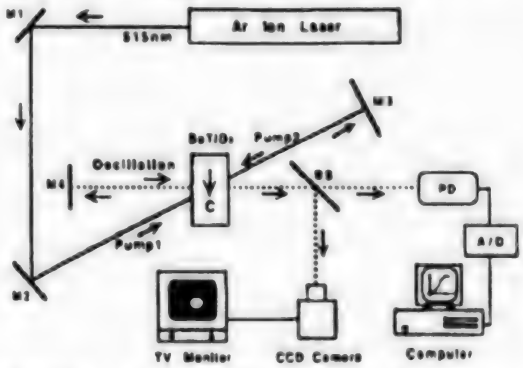


Figure 1. Phase Conjugate Resonator Formed by Four-Wave Mixing

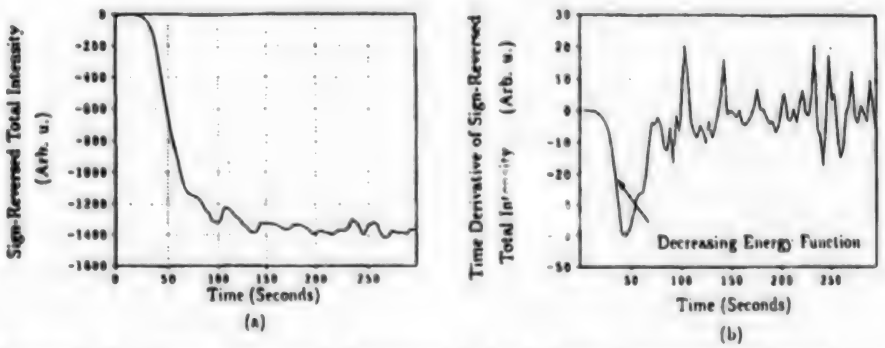


Figure 2. Experimental Results: (a) Sign-reversed total intensity of the optical fields, and (b) its time derivative representing the energy function that decreases monotonically in the weak-field region

Optical Associative Retrieval With Imperfect Key Images

43070015E Tokyo TOKYO UNIVERSITY, ADVANCED S&T RESEARCH CENTER REPORT in English Mar 93 pp 209-211

[Article by Jumpei Tsujiuchi and Katsuyuki Okada, Department of Image Science, Chiba University]

[Excerpts] **Abstract**: The math advantage of optical computing is its inherent abilities of high-speed operation and parallel processing. In this project, we propose a joint transform correlator with a photorefractive crystal, that recognizes objects in real time from a flexible set of images. To take advantage of the full coherent operation system, complex amplitude modulation is used for coding the objects and references.

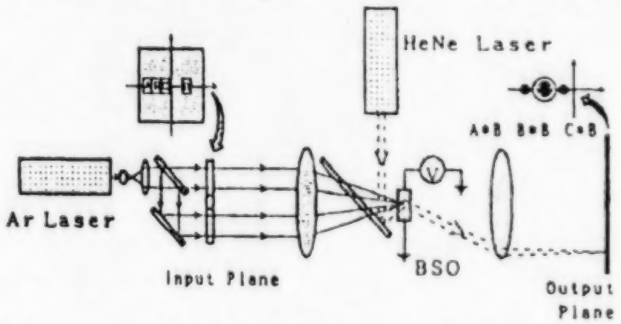


Figure 1. Schematic Diagram of Joint Transform Correlator With a Photorefractive Crystal

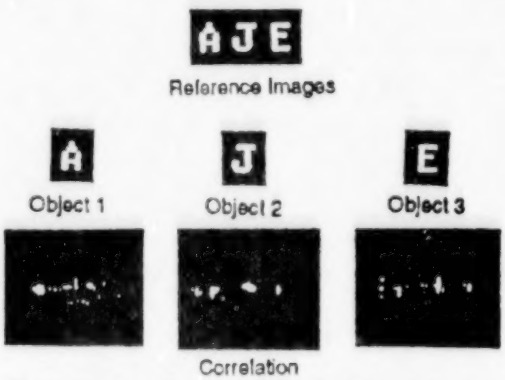


Figure 2. Images of References, Objects and Obtained Correlation Peaks

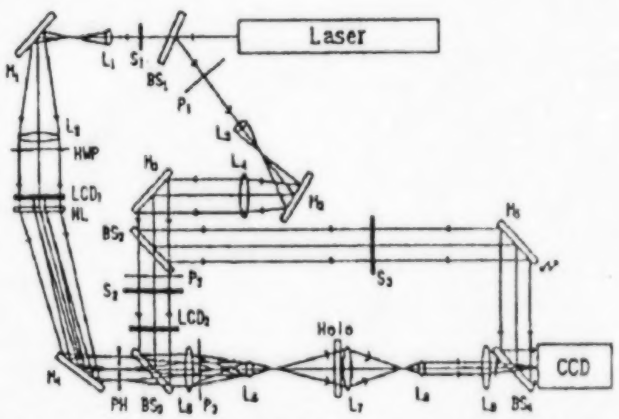


Figure 3. Holographic Associative Memory With a Liquid Crystal Spatial Phase Modulator

Real-Time Processing of Two-Dimensional Image in Organic Dyes

43070015E Tokyo TOKYO UNIVERSITY, ADVANCED S&T RESEARCH CENTER REPORT in English Mar 93 pp 212-215

[Article by Hirofumi Fujiwara, Department of Material Science and Engineering, Muroran Institute of Technology]

[Excerpt] **Abstract**: Nonlinear optical properties of organic dye doped polymer films are suitable for two-dimensional optical information processing. We investigated an optically addressed spatial light modulator (optically addressed SLM) to encode an input image and transform it to other forms. We found that a methyl-red doped PVA film was available for the optically addressed SLM. Methyl-reds are randomly distributed in space and randomly oriented in a polymer film. The incidence of linearly polarized intense laser beam induces anisotropy such as birefringence and dichromism in the film. Half-tone positive and negative image conversions and optical logic operations of two images were demonstrated with a methyl-red-doped PVA film sandwiched between a polarizer and an analyzer.

Massively Parallel Optical Processing With Learning Capabilities

43070015E Tokyo TOKYO UNIVERSITY, ADVANCED S&T RESEARCH CENTER REPORT in English Mar 93 pp 215-217

[Article by Masatoshi Ishikawa, Faculty of Engineering, Tokyo University]

[Excerpt] **Abstract**: Two different types of optical computing architectures are proposed. One is an optical computing architecture for solving the Poisson's equation that is one of partial differential equations. The architecture requires a feedback type optical system using a spatial light modulator. The other is an optical associative memory using three modified methods: correlation learning method, total activity control and binary memory. A feedback type optoelectronic parallel processing system with optical interconnection is being developed.

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